AMATEUR SATELLITE REPORT

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AMSAT's Newsletter for the Amateur Radio Space Program

Amateur Satellite Report is endorsed by the American Radio Relay League as the special interest Newsletter serving the Amateur Radio Satellite Community

AO-10 Recovery Plans Hinge On Failure Mode

Against a background of very little hard information, AO-10 Ground Controllers and spacecraft engineers made some progress this week in re-acquiring command capability. The Integrated Housekeeping Unit (IHU) experienced a memory malfunction Saturday, 17 May. The IHU is a computer that mediates overall spacecraft operation under software control.

Ian Ashley, ZL1AOX, says he successfully loaded a short software routine on June 19. This caused the beacon to be turned on and off. The Mode B transponder was also turned on for about 20 minutes to judge the battery condition. The normal telemetry routines which report the battery charge are inoperative at present due to the memory problem. The battery was reportedly in excellent condition.

Karl Meinzer, DJ4ZC, was able to load a short message in the IHU memory. This was an additional encouraging sign according to sources.

It is unknown what specific memory failure mechanism is at work. One possibility pointed to by IHU designer Steve Robinson, W2FPY, is that an accumulating charge on the IHU's NMOS memory is progressively corrupting the data stored in it.

In a variation on this theme, Phil Karn, KA9Q, suggests the affected area may be the memory sense amplifiers. If this is true, the accumulated charge may have lowered the sense amp's threshold to where every cell is read as a "1". At first it was thought the error correction matrix was at fault. That theory has since been supplanted by the W2FPY theory.

W2FPY further points out that some of the effects of radiation are reversible while others are not. If, he says, power is removed from the IHU for a sufficient time, the accumulated charge may dissipate and the memory could return to nearly full capability. Some crystal lattice defects introduced by the impact of radiation are not reversible, however.

One scenario illustrated by Phil Karn, KA9Q, was this. The attitude of the spacecraft is not currently controllable; it will continue in the current attitude indefinitely. The AO-10 attitude with regard to the orbital plane will stay fixed. Moreover, the relationship between the orbital plane and the stars will remain fixed (to a close approximation). However, the relation between the attitude of AO-10 and the earth and sun will change with the seasons.

W3GEY joins P3C in thermal-vacuum chamber at Martin-Marietta, Denver.

According to KA9Q and James Miller, G3RUH, due to normal seasonal geometry changes, by September the sun angle will increase to 90 degrees. At 90 degrees the solar panels receive effectively no illumination.(See Box) Some period prior to then, the battery shall have been discharged and the spacecraft will be essentially dead.

But this may not be the end of the story! This hazardous period could be likened to a period of hibernation or suspended animation if the process is well understood and managed. If the undesirable accumulated charge on the memory dissipates due to natural processes with power removed as forecast by W2FPY, the the memory may actually return to normal operation later this year. The questions are these: Do we really understand what is going on? Assuming we do, what can we do now to improve recovery prospects?

Ron Dunbar, WØPN, expanding on this theme, has de-

veloped an analysis of the options available now and in the future. In his view, there are certain actions which can be now undertaken which will insure the IHU passes as quickly as possible through an "indeterminate" zone of DC power. This is a domain of IHU power voltage in which operation is erratic and unpredictable. Ron points out that several potentially serious consequences could result if random code executes in such a way as to, for example, turn on the magnetorqers. Ron's strategy would reduce the length of time the IHU power bus remains in a hazardous domain and thus maximize recovery prospects.

Also looking into recovery prospects is Dick Jansson, WD4FAB, thermal design engineer on AO-10. Dick is examining the effects of very poor sun angles on overall spacecraft temperatures. John Fox, WØLER, is similarly examining battery prospects and whether it is better to charge the auxiliary battery now, before power is lost, or later after it is restored. What will happen to the primary and auxiliary batteries and the Battery Charge Regulator are key questions running through all current recovery stratagems. Will the battery freeze? Will it explode due to overpressure?

In general, AO-10's condition appears stable for the present. It is not available for operation on either transponder. If you should find either transponder on, you should NOT use it. The beacon is currently sending only "idle" characters. With no intervention there is a slim possibility that AO-10's memory could "heal" and be back online and commandable this Autumn.

However, as pointed out in WØPN's extensive analysis and recommendations, there are actions which might now be taken to improve the odds AO-10 will live to see another year or two of active operation. These recommendations are under study at present.

According to AMSAT President Vern Riportella, WA2LQQ, "Given the lack of a clear picture as to what is actually going on with the memory, educated guesswork and hoping we're on the right track is the best that can be expected for now." Rip added, "We have some really sharp people working the problem and I'm confident if there's a way to get another few month's use from AO-10, these folks will find it. It's become an important challenge for all and no one I know is willing to write AO-10 off just yet! Keep your fingers crossed!"

An analysis by Ron Dunbar, WØPN

Given the current attitude of the spacecraft, the position of the orbital plane and the orbital parameters, the sun angle will change from the current value of approximately -8 degrees to -49 degrees by 31 July and to the NO POWER condition of -90 degrees on 11 Sept as indicated by the following chart (courtesy G3RUH):

DATE	SUN ANG (deg)	ALON (deg)	ALAT (deg)	
1986 May 22	8	157.5	21.7	
1986 Jun 5	4	156.1	21.7	
1986 Jun 19	-9	154.8	21.7	
1986 Jul 3	-22	153.4	21.5	
1986 Jul 17	-36	152.1	21.4	
1986 Jul 31	-49	150.7	21.2	
1986 Aug 14	-62	149.3	21.0	) 47% Illum.
1986 Aug 28	-75	147.9	20.7	) 26%
1986 Sep 11	-90	146.5	20.4	) OOPS!
1986 Sep 25	-76	145.1	20.1	)

Ariane V18 Launch Failure Will Delay P3C Launch

The launch failure of a European Space Agency Ariane-2 rocket Friday night, 30 May, has sent an already reeling space launch industry into an unprecedented regime of confusion and concern and will delay the launch of AMSAT's Phase 3C until 1987.

A third stage failure is being blamed for the fourth Ariane failure in 18 launches. Arianespace immediately suspended all plans for future launches pending investigation of the V18 failure.

AMSAT is manifested to fly the first Ariane-4 launcher, the V21 mission. This launch had been scheduled for early November. Arianespace officials said it would be at least 2 months and up to 6 months or more before launches could resume. An "indicative" announcement was expected from Arianespace on June 30 according to Washington-based officials.

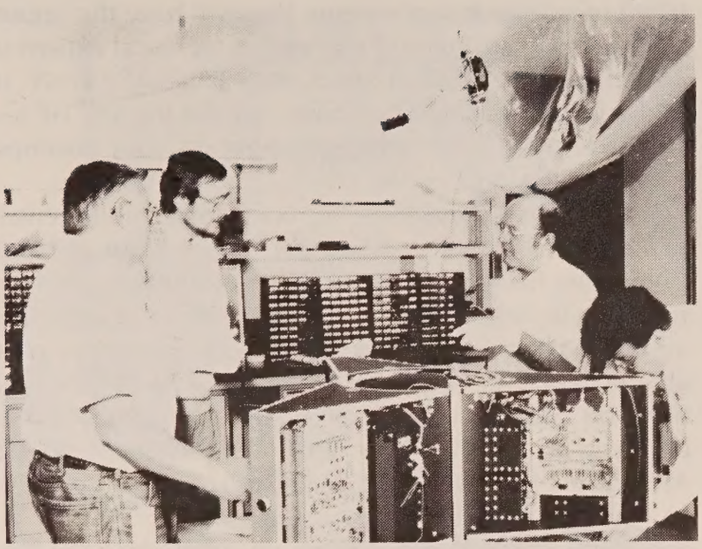
AMSAT will take advantage of the schedule slack to effect some improvements in specific P3C areas. While improvements in the IHU radiation hardness have been discussed for months, even before the current IHU failure episode unfolded in May, a tight schedule limited what efforts could be brought to bear on the problem of a possible memory replacement.

Now, with an apparent launch stand-down of several months at hand, serious consideration is being given to rebuilding the P3C IHU with newer, harder memory chips and simultaneously increasing memory capacity from the current 16k to 32k. The result could be increased P3C reliability, capability and flexibility.

In a recent development, AMSAT has received a preliminary commitment from a major custom IC memory manufacturer for a set of radiation hardened memory circuits to fly on P3C. The preliminary work on the replacement IHU has now begun in the expectation it will fly with P3C next Spring when the Ariane launches may recommence.

Short Bursts

- A new AO-10 ground track overlay is now available. The overlay is scaled to be used with the ARRL OSCARlocator only. It is calibrated for maximum accuracy between June and August, 1986 and is available free for a business sized SASE to: AO-10 Ground Track, c/o AMSAT, P.O. Box 27, Washington, D.C., 20044.
- A brand new software package is now available for the C-64. The exciting new features in Supertrak 64 include a highly detailed map display, ground track path, tracking up



Part of the AMSAT DL team during the P3C integration in Golden, Colorado recently (l-r) Konnie Mueller, DK1YQ, DJ4ZC, DJ5KQ.

to 8 of 14 satellites in the menu and autocall of the QUIKTRAK tabular program. Bob McGwier, N4HY, the designer of Supertrak 64 says that some special software hooks are built into the package so it will run the soon-to-be-available autotracking system from Encomm. The Supertrak package is now available at the AMSAT Software Exchange.

• An English language translation of the new JAS-1 handbook published by JARL is now available from Project OSCAR. Send $10 to: JAS-1 Satellite Handbook Project OSCAR, Inc P.O. Box 1136 Los Altos, CA 94023.

• AMSAT UK will sponsor an Amateur Satellite Colloquium July 5 and 6 at the University of Surrey, Guildford, England. Speakers include G2UK, G3AAJ, G4IQQ, G3YJO, K8KA, KA9Q, DJ4ZC, G3IOR, and others. Small delegations from several European countries were also expected according to G3AAJ.

• The launch of RS-9 and RS-10 is now put in the September time frame. RS-10 is complete and was on display in Moscow recently. The launch of ISKRA-4 has also been postponed due to the end of the school year. ISKRA-4 is being built by students at the Moscow Aviation Institute. The students are now on summer break.

• Effective May 29th, RS-5 and 7 are on a new schedule. RS-5 will be turned on from 0500 to 1000 UTC daily except Wednesday. RS-7 will be turned on daily from 1000 to 1700 UTC except Wednesday. These schedules presume access by the command station in the Moscow area. The schedules will be in effect until August according to UA3CR.

• Andy MacAllister, WA5ZIB, will be heard in an interview airing on Radio Earth in segments over the next few weeks. Andy was interviewed in Houston recently for the broadcast which addresses Amateur Radio satellites. The spot is called "Ham Notes" and airs Mondays and Thursdays between 2300 and midnight EDT on WRNI, a commercial shortwave broadcaster, on 7355 kHz. Duke Alexander is the host for the series. Andy says there is a possibility of re-broadcast on HCBJ from Quito later.

• Thermal-vacuum testing of the Phase 3C (P3C) spacecraft was successfully completed in Denver on Tuesday, June 3rd. Next, the spacecraft will be shipped to West Germany soon for additional tests in preparation for shipment to Kourou, French Guiana for launch next year.

• Photos may now be submitted for possible inclusion in the AMSAT-OSCAR 25th Anniversary Yearbook. Do you have a favorite photo of you and shack? Do you have one which shows your satellite station as it was ten years ago? Twenty? Or even last month? If so, you are invited to submit them for possible inclusion in the yearbook. Please submit all photos with suitable captions. Please include a SASE for return of the photos. Send candidate photos to: Yearbook, P.O. Box 177, Warwick, NY 10990.

• Ron Graham, YJ8RG, departed from Vanuatu last week. He is returning to his homeland to become VK4BRG. Ron had provided valuable help to the AMSAT South Pacific Net on Saturdays at 2200 UTC according to Net Control W6SP.

• The AMSAT Net Survey has generated hundreds of responses and many are quite informative. The survey will be extended through the month of June. AMSAT is interested in knowing where you receive information about satellite activity and what AMSAT nets you may listen to. Your response will be welcome and rewarded with a handy Phase 3C and JAS-1 frequency guide. Send your net listening report together with a business sized SASE to: Net Survey, P.O. Box 177, Warwick, NY 10990.

W5LFL Retires From NASA

Astronaut-Ham Owen Garriott, W5LFL, has announced his retirement from the NASA Astronaut corps. The first "Ham-In-Space" said in an interview that with the next Spacelab mission on the shuttle at least 4 years off, he needs to get on with his life. Owen pointed out he will be "over 60 years old" by the time Spacelab flies again. He will stay on in Houston where he will become a consultant in aerospace. Dr. Garriott holds a PhD from Stanford and, at the time of his retirement, was Chief Engineer on NASA's Space Station Project. The W5LFL flight on shuttle Columbia, 28 Nov thru 8 Dec 83 set a number of historic precedents.

Owen said he will continue to work with the Ham-In-Space program hopefully to prepare the way for other Astronauts to become licensed and operate from space.

New Magazine To Feature Technical Theme

An Autumn 1986 kickoff is planned for a new, optional monthly technical magazine. Plans call for the magazine to be jointly published by AMSAT and a major domestic publisher in amateur radio. Being an AMSAT member will afford the subscriber to this new magazine a preferential subscription rate.

AMSAT has issued a call for articles for the new magazine. Send manuscripts to AMSAT, P.O. Box 27, Washington, D.C., 20044. In addition to the technical merits of articles, good graphic content is important. Your inclusion of good quality photos, together with graphs and line drawings all help make your article more attractive and interesting.

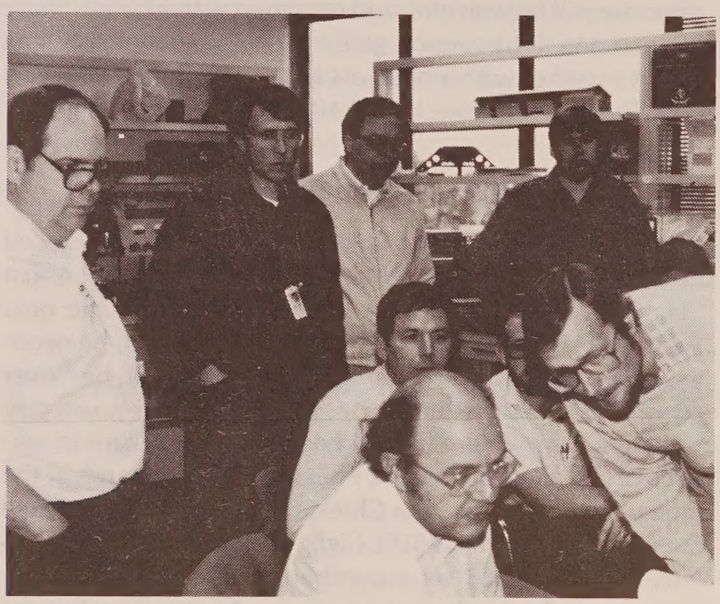
The success of the new magazine is closely tied to the quality of the articles it publishes. And the articles inevitably must originate largely within the satellite community. Participation by a broad cross-section of our community is strongly encouraged; it's vital!

Call For Nominations

AMSAT Headquarters announces nominations for the office of Member of the Board of Directors are now in order. The seats of three directors (Thomas Clark, W3IWI, Vern Riportella, WA2LQQ, and Harry Yoneda, JA1ANG) are up for election in this cycle. Last November four directors — John Henry,VE2VQ, Jan King, W3GEY, John Browning, W6SP, and Harold Price, NK6K — were elected. The term of office is two years.

An AMSAT member who agrees to serve can be nominated by any five current AMSAT members or by an AMSAT member society. Nominating petitions may be sent to: AMSAT, P.O. Box 27, Washington, D.C. 20044.

Petitions must arrive at AMSAT not later than July 31, 1986. Nominees will be asked to provide minimal background and biographical data for inclusion with the ballot forms.



Checking out P3C at Golden, Colorado are, (l-r) standing, KØRZ, W3GEY, WØRPK, DB2OS; Seated DJ4ZC, ZL1AOX, VK5AGR; leaning is DK1YQ.

Annual Meeting and Space Symposium Planning Progress Report

The 1986 AMSAT Annual Meeting and Fourth Annual Space Symposium will be presented in Dallas, Texas, November 7-9, 1986. The meeting will be held at the Dallas-Fort Worth Airport Hilton Hotel/Executive Convention Center.

The events will begin Friday evening with a real Texas style barbecue warm-up party.

The featured Fourth Annual Space Symposium will be presented Saturday with expert speakers from around the world. The speakers will give us the latest on amateur satellites and space technology including JAS-1 and Phase 3C.

Saturday evening the AMSAT Annual meeting and banquet will be held. The banquet Grand Prize this year will be a sparkling new ICOM IC1271A 1.3 GHz all-mode transceiver. Many other prizes totaling over a thousand dollars will be awarded too!

Sunday's activities will have a bonus this year. Concurrent with the Board of Director's meeting there will be a 60-90 minute technical session. You will have the opportunity to talk with some of the leading technical experts in our hobby. As an added bonus, Rick Fogle, WA5TNY, of Bridge Communications will have "state-of-the-art" HP test equipment available to test and tune up your preamps, receive converters, etc.

Since Dallas is a major electronics manufacturing center, numerous electronics surplus outlets are close at hand. Companies like Collins Radio, Texas Instruments and Xerox have facilities for those who would like to rummage around in these surplus stores. Transportation will be available all day Friday November 7, 1986. There may be a small transport charge if vans must be rented to accommodate all. If you plan to take advantage of this service, please call Art Jackson, KA5DWI, at 817-282-0170 as soon as possible so we may plan accordingly.

Pre-registration could pay big dividends for you! Pre-registration Prizes include:

ALINCO 70cm 100 watt power amplifier
EIMAC 3CX100A5 tubes (pair)
DFW HILTON HOTEL: free room during your stay at the meeting.

In order to have a chance of winning one of the pre-registration prizes you must register for the convention on or before September 30, 1986. If you register after September 30, 1986 you will be eligible only for the Main Drawing prizes. All registrants are eligible for the Main Prize Drawing.

AMSAT is in the process of developing a "Wives' Program" for the convention. Details will be provided in *ASR* and the various AMSAT hf nets.

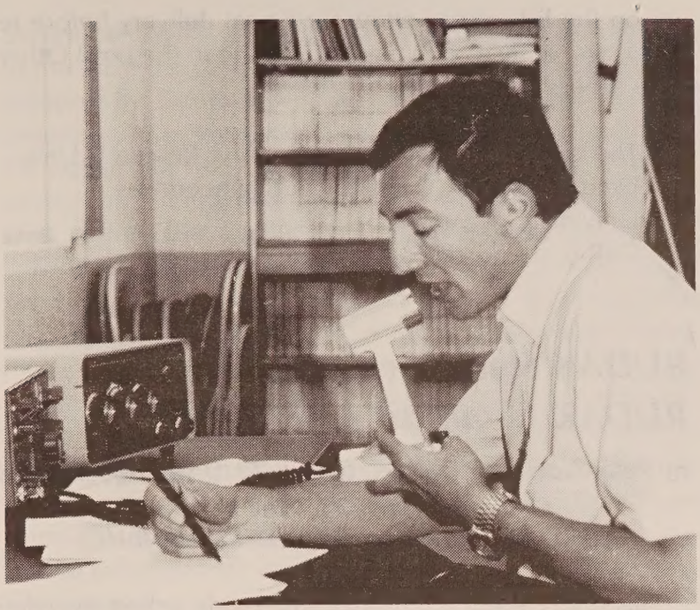
The organizers are putting together a first-rate affair and pass a friendly, " Y'all come and see us in Dallas now, heah!?!"

Introduction To Amateur Satellite Report

Welcome to *Amateur Satellite Report, ASR*. With this issue *ASR* becomes AMSAT's flagship publication. It is being sent to all AMSAT members worldwide.

ASR was born five and one half years ago as a special-

A moment of reflection at Golden. (l-r) WA2LQQ, DJ4ZC.



AMSAT's Sunday 20 meter NCS, Dave Cowdin, WDØHHU, in action.

purpose newsletter for key AMSAT managers. A circulation of less than 100 was planned. But with a paucity of authoritative, accurate, written, regular information available to members, many more found they needed *ASR*. Available by separate subscription only, *ASR* circulation grew to more than 1200.

Now AMSAT has decided to swap the roles of its magazine and *ASR*. Henceforth *ASR* will be sent to all members as a membership benefit. And a new, optional monthly technical magazine will be available shortly.

As explained in a general mailing in April, the primary motivation for this transition is to provide satellite users with what they want the most: timely news about operating conditions. If hard-core technical information is desired as well, it will be available in the new, optional magazine. Unfortunately, the hard, cold economic realities of the cost of publishing a small, limited circulation magazine prevent AMSAT from doing both without substantially raising membership dues AND going back to Life Members for additional support.

Moreover, as we have learned in recent years, the complexity of producing a quality magazine in a volunteer environment is generally poor appreciated. In a volunteer environment schedules are "mush". Unfortunately, magazines do not get produced with "mushy" schedules.

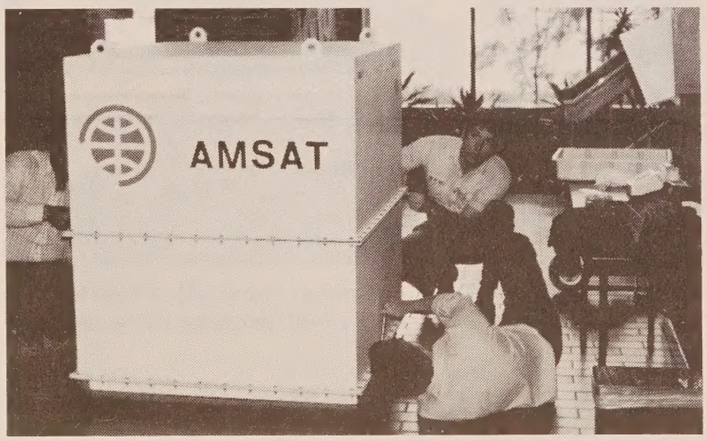
AMSAT President and former *Orbit* Magazine Editor put it this way: "If well-meaning but busy contributors routinely miss deadlines (as very often occurs in a volunteer publication such as *ORBIT*), then it's my premise that the probability of getting a magazine out on time varies inversely with the square of the number of people involved; I dunno; maybe it's the inverse cube! But I can tell you this. When you have a dozen volunteers all marching to a different beat, the chance of them all coming down on the right foot concurrently is pretty slim. Witness *ORBIT* and later *ASJ*. "People have asked why AMSAT can get *ASR* out the door fairly regularly, about every two weeks, but not *ORBIT* or *ASJ* every two months even though the rate of "paper production" is roughly the same.

"It's just the number of people involved and the ability to meet deadlines. I think the deeper answer lies in the nature of a volunteer organization. Unfortunately, things like making a living get in the way of many things we would otherwise like to do...like hold rigid schedules! That, incidentally, is one of the major reasons for teaming with a major domestic publisher for our new, optional monthly magazine. With its paid, professional editorial staff, the problems of meshing schedules among volunteers will be a thing of the past."

In a recent poll, 87 out of 100 AMSAT members approved of the change given that both a magazine AND a newsletter could not be supplied without raising dues. *ASR* will normally be a 4-page bi-weekly self-mailer mailed second class to all members. This issue is an 8-pager because of the need to get a large volume of news out promptly. Some of the stories covered in this edition are updates or repeats of stories recently covered in *ASR*. This was necessary to cover some formalities such as the "Call For Nominations" article which must go to all members. In the future, *ASR* will update stories as appropriate in subsequent editions but will unlikely rerun any stories.

Those who have previously paid for *ASR* subscriptions will be offered a credit certificate good for future AMSAT publications or, if they find it appropriate in helping AMSAT, they may donate their un-fulfilled *ASR* subscriptions to AMSAT's general revenue funds.

ASR will be covering the latest in satellite news in the clear, authoritative style that has made it a major vehicle



The P3C spacecraft is secured in its shipping container at the Solar Energy Research Institute in Golden, Colorado. ZL1AOX, facing camera, tightens a bolt.

for news of the Amateur Space Program. Accenting the news reports will be quality photos illustrating the happenings and interesting vignettes from around the satellite world. Orbital predictions will be carried as they always have been but with a frequency inversely related to the altitude of the satellites. Thus Mir, at 350 km, will be documented frequently and AO-10 infrequently since low orbits change quickly and high orbits hardly change at all.

ASR will be introducing some new features in the near future. The "Tech Tips" column will show you some quick and easy ways of handling common questions and problems in the tradition of QST's "Hints and Kinks" column. The *ASR* "Mini-Tutorial" which has previously been so popular will return on a regular basis. And the popular "Spotlight" coverage of AMSAT members will make a return after an absence of several years. All this and more in your new pub, *ASR*!

Salyut-7 To Burn Up In Planned Fiery Re-Entry

Reports indicate the two Russian Cosmonauts now aboard Salyut-7 will soon return to the Mir space station. About two weeks after the transfer, Salyut-7 will be intentionally de-orbited and burn up upon re-entry. This could occur before mid-July. The Cosmonauts will then reside in Mir until the end of December. In the interim they will build Mir up with a series of huge modules to make up a 100 ton monster-craft more than 150 cubic meters in volume. The component modules will be launched over the next several months using the new Soyuz TM launcher as well as the Progress launch system. The re-entry of Salyut-7 presumably over the Pacific should be a spectacular fireworks show due to its high mass. Thanks PAØDLO.

JAS-1 Orbital Elements

Launch of the first all-Japanese satellite, JAS-1, is now just a few weeks away. Launch is currently scheduled at 2030 UTC, 31 July 1986 according to a note by James Miller, G3RUH, with acknowledgement to "OSCAR News".

The following Keplerian elements have been supplied for JAS-1:

Ref Epoch: 86212.897306 UTC
Inclination: 50.004 deg
RAAN: 237.456 deg
Eccentricity: 0.0001407
Arg. of Per: 2.155 deg
Mean Anomaly: 330.246 deg
Mean Motion: 12.412719 rev/day
Decay: 0 rev/day/day
Epoch Rev: 0
SMA 7879.56 km
Beacon: 435.795 MHz

UoSAT Data Booklet Now Available

A new, revised and enlarged edition of the UoSat Data Sheets has been produced by the UoSAT Team. It is now available from the University of Surrey, England, as a 40-side booklet. Send a stamped, addressed envelope to the address given below. A small donation to cover printing costs (suggest the equivalent of $3.00 U.S) is very welcome.

Contents of the booklet is as follows:

Section	Contents
1	UoSAT-OSCAR-9 (UoSAT-1) Mission Summary
2	UoSAT-OSCAR-11 (UoSAT-2) Mission Summary
3	UoSAT-OSCAR-9 (UoSAT-1) Technical Data Summary
4	UoSAT-OSCAR-11 (UoSAT-2) Technical Data Summary
5	UoSAT Orbits and Tracking
6	UoSAT-OSCAR-9 (UoSAT-1) Spacecraft Data Formats
7	UoSAT-OSCAR-11 (UoSAT-2) Spacecraft Data Formats
8	UoSAT Whole-Orbit-Data (WOD)
9	UoSAT Spacecraft Telemetry Calibration Equations
10	UoSAT-OSCAR-11 Digital Communications Experiment
11	UoSAT CCD Camera and DSR Experiments
12	UoSAT Ground-Station Equipment

Over 720 copies were recently posted from UoS to all those on the UoSAT Mailing List. If you believe that you are on the list, please allow for postal delivery before requesting a copy as one may already be in the post! Otherwise send your SAE to:

The UoSAT Spacecraft Engineering Research Unit,
Dept. Electronic & Electrical Engineering,
University of Surrey,
Guildford, Surrey, GU2 5XH. ENGLAND

RUDAK Status Report of the RUDAK Group of AMSAT-DL

by Peter Guelzow, DB2OS, Deputy RUDAK Project Leader
April 27, 1986
(translated by Don Moe, KE6MN/DJØHC)

This status report is intended to provide a short overview of the results achieved thus far in the construction of the RUDAK experiment for the AMSAT Phase 3C satellite.

First a short review of the sense and purpose of RUDAK:

"RUDAK" stands for "Regenerative Umsetzer fuer Digitale Amateur Kommunikation" (in English: Regenerating Transponder for Digital Amateur Communications). It is comparable to a so-called digipeater (Digital Repeater). Digipeaters are terrestrial relay stations for packet radio. They relay digital information between two stations in case there is no direct path between them. The transmission occurs in packets (therefore the name packet radio). The actual information is subsumed within a frame which contains the callsigns of the sending and receiving stations and an entire set of additional entries necessary for forwarding and error handling. In this way packet radio makes possible virtually 100 percent error-free information transmission. The format of these packets was internationally established using the so-called AX.25 protocol.

Similarly to analog transponders, it seems desirable to install such a digipeater at the highest possible location with a large coverage area, e.g., aboard a satellite in earth orbit. Thanks to the highly elliptical orbit of Phase 3C, RUDAK should eventually enable the interconnection of several local area nets in addition to point-to-point contacts between radio amateurs across the entire world. Naturally a relay station with such a large coverage area has to contend with a series of difficulties. For example, the problem of multiple uncoordinated access or the selection of optimal modulation techniques are only two of among many that could be mentioned. These and other problems are to be researched primarily with the help of RUDAK with the goal of developing suitable techniques and protocols which will benefit future projects.

Status of the hardware development:

The initial designs of the RUDAK experiment were determined at a working meeting at AMSAT-DL in Marburg, West Germany in February 1985. Later, in July 1985 in Marburg the entire hardware design, the IHU interface as well as the satellite interface were presented. After certain modifications were agreed, the first functional wire-wrap prototype, RUDAK #1, was unveiled on the 6th and 7th of

September. At this meeting in Marburg the primary task was to integrate the programming language IPS, previously developed by Dr. Karl Meinzer, DJ4ZC, into the RUDAK processor. After several software errors were eliminated, IPS-CR was at last successfully loaded into RUDAK. The successful implementation of the IPS system brought the RUDAK experiment a giant step closer to completion.

The first printed circuit version, RUDAK #2, supplemented the original wire-wrap version a short time later. In all, the plan calls for four double-sided circuit boards with plated-through holes with the dimensions of 290 x 180 mm. Two boards will be built as identical flight versions with one serving as a reference model on the ground. The other flight version will be mounted together with the demodulator and the power supply in a two section housing with the dimensions of 300 x 200 x 20 mm and 300 x 200 x 17 mm. This will be subsequently integrated into the Phase 3C satellite. The remaining circuit boards are reserved for software development and various tests such as radiation testing. The boards were laid out using a CAD/CAM system.

The hardware development of the RUDAK processor is completed. The main work now involves the completion of the flight version as well as the implementation of the AX.25 protocol.

On 24 and 25 January 86, the RUDAK group met once again in Marburg to clarify remaining details regarding integration into the satellite. A further high point was the demonstration of RUDAK's capabilities. For the first time, four TNC-1's were linked together via the RUDAK processor, simulating on hard-wire connections how the operation will later take place. TAPR TNC-1's were used exclusively though only one had the original TAPR software; the other three used the multi-connect firmware from WA8DED. A lively data exchange took place and DJ4ZC made his first packet radio QSO. Additionally, RUDAK transmitted some general information in beacons. As was to be expected, numerous collisions occurred. Even so, RUDAK demonstrated that it already was working correctly. The next milestone is the 10th of May, when the RUDAK flight version has to be ready for integration into the Phase 3C satellite.

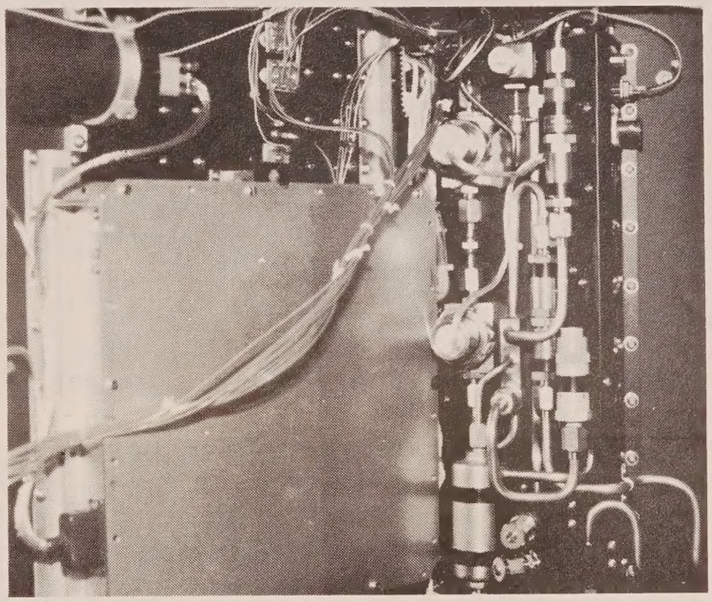
Details about the RUDAK hardware:

The RUDAK hardware consists of 25 integrated circuits and only two discrete transistors. The entire circuitry was realized using CMOS technology so power consumption is only 300 milliwatts. The heart of the RUDAK processor is the CMOS version of the 6502 CPU which is clocked at 800 KHz. For storage of the RAM-resident system software and data, 56KB of static CMOS RAM chips are provided. This concept itself gives RUDAK greater flexibility in case, for example, the entire RUDAK software has to be updated due to changes in the protocol as has already been practiced with OSCAR-10's IHU. A single 2KB fusible link CMOS PROM is used to load the IPS system via the command link after power-on. Additionally, the boot PROM contains various programs which will perform tests of the entire hardware in the RUDAK processor while in orbit.

To communicate with the outside world, the RUDAK processor has various parallel and serial input/output ports. One serial line and one 8 bit parallel port with the appropriate control lines are used for communication with the IHU. In the start-up phase, these paths are used to transfer diverse command and diagnosis instructions. Later, using this same path, RUDAK can receive current telemetry data which can be processed further. The IHU can also use a portion of the RUDAK memory as virtual memory in which to store larger quantities of data, e.g., RTTY/PSK bulletins. The capacity of the 16KB RAM in the IHU is already totally used.

Normal operation with ground stations is handled by the RUDAK packet port. One send and one receive channel are available. The heart of this port is the CMOS version of the Z80-SIO, a universal chip which supports the AX.25 protocol in addition to asynchronous and synchronous operation.

An independent receiver in the Mode-L transponder is provided for the RUDAK uplink on 1269.675 MHz. The demodulator converts the 2400 bps biphase PSK signal into



Some of the P3C plumbing, a product of W4PUJ's handywork, is seen here. This is the propellant flow assembly.

a clean digital signal for the RUDAK processor. Thanks to the sweep circuit in the demodulator, the uplink signals only have to be in the capture window within plus/minus 7.5 kHz of the center frequency.

On the downlink side, the output data modulates the RUDAK beacon transmitter in the L-transponder on 435.675 MHz using BPSK at a data rate of 400 bps; the same as for the general beacon of OSCAR-10. Experimentally, the rate can be increased to 1200 bps using NRZI modulation.

A short note regarding the modulation methods used:

The 2400 bps uplink and the 400 bps downlink signals are generated using the AMSAT standard just the same as for the general beacon of AO-10. In the AMSAT standard, the data bits are transmitted differentially, i.e., a logical "0" is sent when there is no change in two successive bits, whereas a logical "1" is sent for a change between bits. Additionally the clock signal is combined with this data stream. Due to this trick and the differential encoding, the design of the decoder is significantly simplified.

Unfortunately another standard has established itself internationally in which the assignment of the logical levels is exactly reversed. In the NRZI standard, a logical "1" is transmitted when there is no change between bits. If the

bit clock is also combined with the data, the signal is then called "NRZIC". In order to reduce the confusion as much as possible, it was decided to adopt the previous AMSAT standard for RUDAK. In the case of the 1200 bps downlink option, the NRZI standard was chosen, and, in contrast to the AMSAT technique, the clock signal is not combined with the data, since to do so would exceed the bandwidth of the SSB receiver.

Requirements for the ground stations:

In the initial stages, RUDAK will emulate the existing digipeater functions as they are defined the AX.25 protocol version 2. No mailbox operation is planned presently although various other messages such as bulletins, orbital data, telemetry values and user instructions can be cyclically transmitted when no uplink signals are being digipeated. New ground stations can take their time in adjusting their receiving equipment.

Additionally, a robot-type operation is planned in which the ground stations "connect" to the satellite and are assigned a consecutive number. In a fashion similar to the RS satellites, a RUDAK command station could later download the list and send out QSL cards. It is also hoped that an overview of packet radio activity world-wide could be thereby obtained. Should a suitable link-layer level 3 protocol subsequently become available, it could possibly be implemented.

For the majority of the terminal node controllers, e.g., TAPR TNC-1, AEA PKT-1 or Heath HD-4040, the only software modification required is an updated EPROM to handle a hardware bug in the WD1933/35 HDLC controller. Otherwise only a PSK modem for 400/2400 bps has to be connected to the external modem jack in the TNC. Other TNC's such as the Kantronics "Packet Communicator" or various software solutions are unfortunately not suitable due to the software and/or hardware restrictions. The TNC must be capable of operating full-duplex at different transmit/receive baud rates and support the connection of an external modem.

Besides the normal equipment, a so-called "RUDAK User Interface" is required. This is under development by the RUDAK group and AMSAT-DL. The RUDAK User Interface consists of an up-converter which translates a 2m signal to 24cm and modulates the carrier with 2400 bps BPSK and the "AMSAT-AFREG" which is the BPSK demodulator for the 400 bps downlink. Additionally various buffers and controls for switching the different signal paths and a power supply are needed. The various schematics, especially for the AMSAT-AFREG and the upconverter, will be published by AMSAT-DL after the design is completed.

On the RF side of the ground stations, the 400 bps downlink signal on 435.675 MHz should provide a signal strength of 12dB Eb/No to an antenna with 10 dBi gain. For the uplink on 1296.675 MHz, 12 watts (11 dBW) into a 15 dBi antenna should be sufficient.

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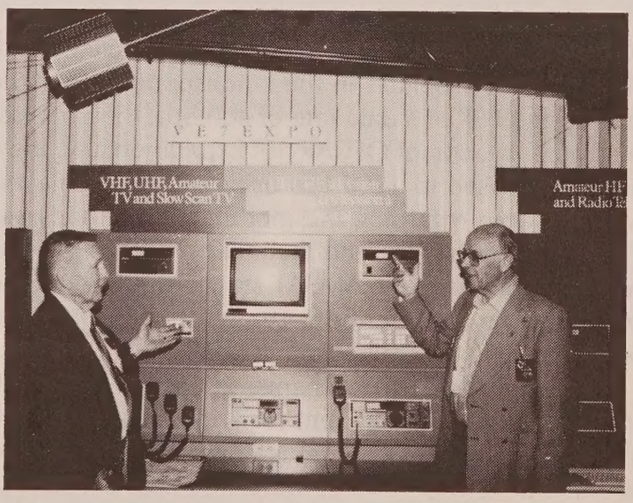

Tony, VE7XQ, left, with Walter, OZ9BR at the Ham Station at Expo 86 in Vancouver, BC Canada.

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